ESRF	**Experiment title:** Induced magnetic order in Nd/Pr superlattices	**Experiment number:** HE-296
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Report:

Nd/Pr is the first system where it has been possible to study the magnetism of both components of a superlattice separately using resonance-enhanced magnetic x-ray scattering *(Experimental Report* HE-108). The narrow wave-vector transfer resolution of x-rays enables the magnetic structure to be studied more closely than before, and the energy resolution at the resonance gives detailed information on the electronic state of the magnetic species. A single-crystal $[Nd_{33}Pr_{33}]_{50}$ superlattice grown using molecular beam epitaxy was studied in this experiment. This has a thicker Pr layer than the previous sample, and the aim here was to gain insight into the magnetic coupling mechanisms in artificial metallic superlattices.

Magnetic resonances were observed at the L_{II} absorption edges of both Nd (6.722 keV) and Pr (6.440 keV). At T ~ 2 K shoulders were detected in energy scans at the two edges. This shows that there are two resonances in each case. The observed energy splitting, a few eV, is comparable to the energy separation between 5d and 4f electrons, suggesting that the two components correspond to dipolar *(2p-5d)* and quadrupolar (*2p-4f*) transitions. The results support the view that the induced order in the Pr is localised at low temperature.

Figure 1 compares scans of wave-vector transfer in the c* direction through magnetic peaks at the Pr and Nd L_{II} edges at selected temperatures. These scans give information on the propagation of magnetic order through the superlattice. For coherent magnetic structures

superlattice peaks are detected offset from the average magnetic Bragg peak by $2\pi/\Lambda$, where A is the bilayer repeat. The moment profile through the magnetic blocks determines the enveloping function, and the presence of strong superlattice peaks either side of the average Bragg reflection indicates a square-wave moment profile. This is observed at all temperatures for Nd, and the similar results for Pr at T ~ 2 K shows that a uniform moment is induced across the 100 Å Pr blocks at low temperature. At higher temperatures the superlattice peaks decrease in intensity relative to the main Bragg peak at the Pr edge, and can no longer be detected by $T \sim$ 10 K. This is interpretted as a fall-off of the induced moment away from the interfaces with the Nd. The magnitude of the induced moment can be compared with the Nd moment by measuring magnetic and structural intensities at the two edges, and the Pr moment is found to fall relative to Nd as the temperature rises. The induced moment is very small by $T \sim$ 12 K, and the broadening of the peaks at the Nd edge at this temperature shows that this leads to a decrease in the coherence of the Nd magnetism.

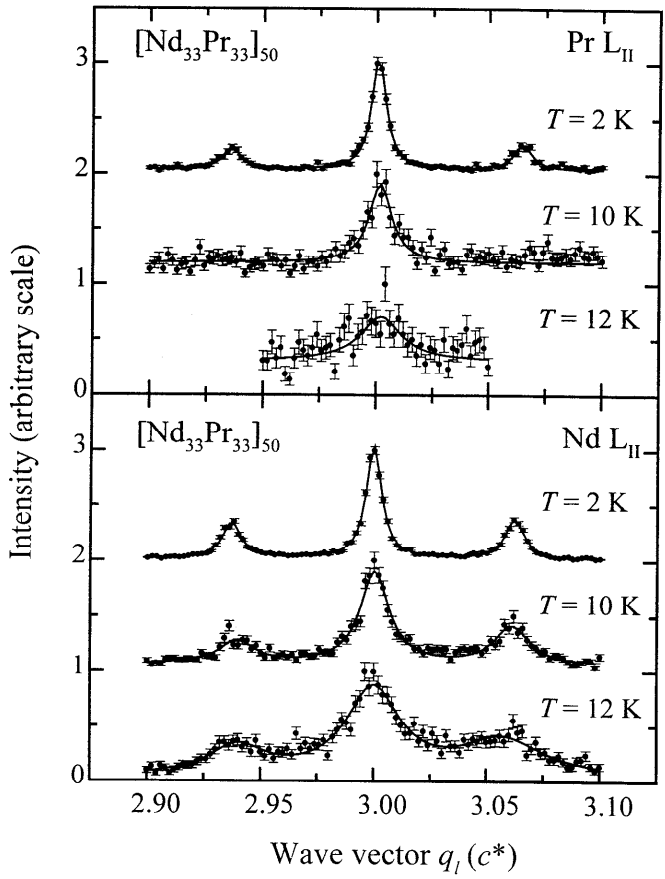

Fig. 1. Scans of wave-vector transfer in the c*direction through a magnetic reflection.